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Article — Published Version

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Small Business Economics

Provided in Cooperation with:

Springer Nature

Suggested Citation: Heller, David; Karapanagiotis, Pantelis; Nilsen, Øivind A. (2025) : Small and vulnerable during crises? Firm size and financing constraint dynamics, Small Business Economics, ISSN 1573-0913, Springer US, New York, NY, Vol. 65, Iss. 1, pp. 451-473, <https://doi.org/10.1007/s11187-024-00996-y>

This Version is available at:

<https://hdl.handle.net/10419/323679>

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Small and vulnerable during crises? Firm size and financing constraint dynamics

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Accepted: 24 December 2024 / Published online: 24 January 2025
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Abstract This study analyzes the dynamics of financing constraints under changing economic conditions and the role of firm size in this context. Using administrative data from Germany, we quantify financing constraints expressed as the probability that a firm encounters excess demand or excess supply. On average, small- and medium-sized enterprises (SMEs) are indeed more likely than larger firms to face excess demand for loans. Using the Great Financial Crisis as an empirical setting, we show that tightening financing conditions do not affect smaller firms disproportionately, but generally risky borrowers. Importantly, post-crisis trends in debt-ratios, profitability, investments,

and employment are similar irrespective of firm size, while smaller firms respond to the economic slowdown by persistently building up cash buffers. Our results urge policymakers to consider specific characteristics of bank-dependent firms to assess their exposure to economic crises—instead of focusing on size as vulnerability criteria per se.

Plain English Summary During the Great Financial Crisis in 2009, smaller firms tended to build up their cash reserves faster than their larger counterparts. Post-crisis, both SMEs and large firms showed similar trends in debt, profitability, and employment. Thus, the principal implication of this study is that policymakers should focus on specific risk-related characteristics of firms to assess their vulnerability during crises, instead of implementing blanket policies based on firm size.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s11187-024-00996-y>.

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Keywords Financial constraints · SME financing · Firm-level data · Bank financing · Small business resilience

JEL Classification D22 · D53 · G01

1 Introduction

Using external financing to leverage business operations facilitates firm-level growth and fosters real economic activity (Beck et al., 2006; Carpenter & Petersen, 2002; Holmström & Tirole, 1997; Rajan & Zingales, 1998). Financing constraints limit firms' flexibility to

operate, especially during turbulent market conditions. Small- and medium-sized enterprises (SMEs) are typically considered to be particularly exposed to economic downturns (D'Amato, 2020; Eggers, 2020; Vermoesen et al., 2013) due to their inherent informational opacity and associated agency problems (e.g., Audretsch 2002; Berger and Udell 2006; Faulkender and Petersen 2006). Consistently, preserving the financing conditions of SMEs during times of economic distress is a common objective pursued by policymakers.¹

The Great Financial Crisis of 2009 arguably marks the most severe financial crisis in recent history, urging policymakers and regulators to soften its effects on the most vulnerable firms. The former ECB president Mario Draghi declared that he would do “whatever it takes” to save the European economy and, in particular, its SMEs. More specifically, large-scale programs were initiated to support small firms, such as the ECB's Outright Monetary Transaction (OMT) program.

While these programs certainly fueled the supply of loans (Ferrando et al., 2019; Udell, 2020), they also led to inefficient loan allocation as the policy instruments did not distinguish firms that were in need for help from those that were not (Acharya et al., 2019). Indeed, several studies suggest that financing conditions of SMEs do not disproportionately deteriorate in economic crises compared with larger firms (Atanasova & Wilson, 2004; De la Torre et al., 2008; Kahle & Stulz, 2013; Kremp & Sevestre, 2013; Presbitero et al., 2014).² Despite the usual liabilities of smallness, empirical evidence casts doubt on the view to classify SMEs as vulnerable by default: large and small firms adjust their financing patterns during recessions by increasing trade credits (Carbo-Valverde et al., 2016), accumulating cash holdings (Kahle & Stulz, 2013), or reducing investments (Almeida et al., 2009).

In this paper, we provide new evidence on the debate about the dynamics of financing conditions of small firms. To this end, we assess how financing constraints evolve over the business cycle, comparing SMEs and large firms. Moreover, we track these firms' capital

structure and other financing variables throughout the Global Financial Crisis. In doing so, this paper sheds light on a set of questions: Do economic slowdowns affect SMEs more strongly than large firms? How do constrained firms adjust their financing and other real economic activities over the cycle? How did the crisis affect the activities and recovery of both SMEs and large firms?

Financing constraints are not directly observable such that empirical investigations rely on indirect proxies (Farre-Mensa & Ljungqvist, 2016). Most firm-level approximations apply to only certain firms, for instance, those that actually pay dividends or have bond ratings (see, e.g., Kaplan and Zingales 1997; Faulkender and Petersen 2006; Whited and Wu 2006). Others, like (Hadlock & Pierce, 2010), are applicable more broadly using firm characteristics such as size and age. These firm-level measures typically have in common that they define *being small* as a constraint a priori. This attribute creates a challenge for our empirical analysis, regardless of whether it is indeed true that smaller firms are particularly susceptible to financing constraints.

To solve this challenge, we use a disequilibrium model based on observable firm characteristics, which enables us to estimate demand and supply for bank loans (similar to, e.g., Atanasova and Wilson 2004; Kremp and Sevestre 2013; Carbo-Valverde et al. 2016). We deploy the estimates of demand and supply to determine the probability of excess demand as a proxy for firms' degree to be financially constrained. Thus, we assess the degree of being financially constrained in a continuous space such that our results are not dependent on an equivocal threshold that defines whether a firm is constrained (or not).

We apply this methodology using administrative data from Germany, the largest economy in Europe. The German economy provides an ideal setup for the research questions at hand because it is traditionally bank-based with close bank-industry relationships (Beck & Levine, 2002; Schmidt & Krahen, 2004) while having a distinctively strong SME sector (Audretsch & Elston, 2002; De Massis et al., 2018). Combined, the strong dependence on bank financing and its direct use for investment suggests that changes in underlying financing conditions should have measurable effects on German SMEs in terms of borrowing activities. Furthermore, due to its central role in the European economy, implications of adverse shocks to firm-level activities in Germany indirectly affect firms

¹ Figure 6 (Appendix 2) graphically illustrates the increased focus of policymakers on SMEs' access to credit throughout the Financial Crisis in 2008.

² Aggregates statistics on the Great Financial Crisis in Germany back these findings, indicating that firms' perceived restrictiveness to obtain bank credits at the outbreak of the crisis was stronger for large than for medium-sized or small firms (Ifo Institute, 2019).

in other member states, too. Hence, adjustments in firms' borrowing activities and bank lending potentially transmit across national borders. Our sample consists of high-quality, firm-level data from the German Bundesbank, including firm balance sheets, profit and loss, and other descriptive information. The final dataset comprises about 20,000 firms for the years 2006 to 2015, out of which about 75% are SMEs.

Our analysis discloses several findings on the dynamics of financing constraints for SMEs and large firms. First, we confirm that SMEs, relative to large firms, are on average indeed more dependent on bank debt, carry higher risk, and have a lower availability of collateral. Second, we find that the probability of being financially constrained is higher for SMEs than for large firms. However, during the economic slowdown, this probability increased between 2008 and 2009 somewhat stronger for large firms (7.7%) relative to SMEs (3.6%). Third, as an immediate response to the recession, *all* firms, irrespective of size, cut borrowing and investment. Both SMEs and large firms further responded by building up cash buffers, which confirms recent evidence on firms' mitigation strategies to negative bank-loan supply shocks (see, e.g., Meinen and Soares 2022). Fourth, conditional on being financially constrained, there are very similar recovery patterns for SMEs and large firms, in terms of the use of debt, capital expenditures, and employment. Again, financially constrained SMEs responded to the deteriorating economic conditions by building up persistent cash buffers. This may suggest that SMEs substitute cash for external debt financing, which is consistent with theoretical considerations, i.e., the pecking-order theory (Jensen & Meckling, 1976), and recent evidence that reports a secular decline in bank lending, in particular of SMEs (e.g., Dell'Ariccia et al. 2021; Falato et al. 2022).

The findings of this paper enhance our understanding of the dynamics of financial constraints. We extend prior research on SME financing activities in the German context that uses developments in the 1980s and 1990s as the empirical setting (Audretsch & Elston, 2002; Czarnitzki & Hottenrott, 2011). Our focus is on a more recent economic setting, including the likely most impactful economic crisis since the Great Depression. Further, we contribute to a central stream of the literature on small business economics by investigating small organizations in changing economic environments. Our findings highlight the dynamic organizational capabilities of small businesses discussed in

the literature (Nicolas, 2022; Raymond & St-Pierre, 2013; Wai et al., 2022). As we show, SMEs' operational flexibility helps them to navigate through economic turbulence. Thereby, our analysis contributes to related entrepreneurship literature that examines small firms' adaptive capacities in changing business environments, such as the digital transformation (Bruque & Moyano, 2007; Escoz Barragan & Becker, 2024; Hu et al., 2023; Kurnia et al., 2015). Unlike these studies, our work demonstrates SMEs' flexibility using divestments and cash accumulations to soften the adverse effects of recessions.

Moreover, our empirical analysis incorporates several distinct new features. Previous analyses that deploy disequilibrium models in the context of SME financing (e.g., Kremp and Sevestre 2013; Carbo-Valverde et al. 2016) typically define thresholds that classify firms as constrained or unconstrained. Instead, we examine changes in the probability distribution of excess demand or supply across time, i.e., independent of specific cutoffs. Importantly, we include firms of all sizes in our estimations and, therefore, do not restrict ourselves to the perspective of small firms but evaluate the relative impact. This addition allows us to integrate the literature on the vulnerability of SMEs regarding access to financing (e.g., Audretsch and Elston 2002; Kremp and Sevestre 2013; Vermoesen et al. 2013; D'Amato 2020) into the literature that carves out determinants for small firms' resilience to changing market conditions (e.g., Almeida et al. 2009; Kahle and Stulz 2013; Nicolas 2022; Escoz Barragan and Becker 2024). We thus extend the literature on SME financing by providing a detailed application of measuring financing constraints and comparing the impact of a significant economic recession across small and large firms.

Our findings thus contribute to an important policy debate. European policymakers stress the need to improve access to financing primarily for small firms to stimulate investment and employment. In this context, our results suggest that a more differentiated view on the topic would be appropriate to address the issue of financing constraints effectively. While our results confirm that SMEs are indeed more bank-dependent and have a higher default risk than their larger counterparts, firm size is not equally important in determining financing constraints during recessions. These aspects suggest that policymakers should be most concerned with the underlying causes of what is perceived as the liabilities of smallness, instead of focussing categor-

ically on firm size, to effectively support small businesses.

The paper is organized as follows. Section 2 presents our data, provides descriptive statistics, and outlines the institutional background. Section 3 describes our methodological approach in detail. Section 4 presents the main results, including model extensions. Section 5 discusses the implications, generalizability, and limitations of our analysis. Section 6 concludes.

2 Data and descriptives

2.1 The dataset

The empirical analysis is based on proprietary firm-level microdata provided by the German Bundesbank, the so-called USTAN database. The database contains detailed information on German non-financial firms (e.g., branch, legal form, industry) and their annual financial statements, including profit and loss accounts and the asset history. The USTAN database has been collected annually since 1987 and mainly comprises small- and medium-sized firms. Bundesbank collects these firm-level data within the scope of its refinancing operations, resulting in high-quality, granular data (see Becker et al. (2019) for more details). Table 4 (Appendix 1) lists the original variables (Panel A) and defines the corresponding variables used throughout our analysis (Panel B).³

We use the USTAN database to construct two main datasets. We exclude all firms active in the financial, insurance, and services sectors and those that do not report information on their sector. We also drop observations with below 10,000 Euro of average assets per employee or less than five employees because we cannot reasonably assume them to represent firms that actively participate in financial markets.⁴ For classifying SMEs, its subcategories, and large firms, we follow the recommendation of the European Commission

(2003/361/EC) on the definition of small- and medium-sized enterprises. For any given year, firms are classified as SMEs once they have less than 250 employees and a balance sheet total of a maximum of 43 million Euros. If they exceed these thresholds, they are classified as large firms. See Table 5 (Appendix 1) for more details on the definitions and the sample distributions. We exclude firms that cannot be uniquely identified as belonging to either SME category. Roughly 75% of sample firms are categorized as micro-, small-, or medium-sized. This number is certainly lower than the actual share of SMEs in Germany. However, our sample criteria enable us to preserve the most relevant observations while maintaining a rich enough basis to conduct a thorough analysis.

For the main analyses of the impact of the Financial Crisis on German firms, we restrict the time frame to the years 2006–2010, capturing both the boom period before as well as the bust period after 2008. To avoid survivorship bias, we allow firms to enter and leave the database freely as long as they do not enter after 2008. The resulting dataset covers 74,561 observations, equivalent to 18,113 firms, for the period of 5 years. The sectoral distributions of firms are displayed in Table 6 (Appendix 1).

For the supplementary analysis of firms' recovery, we construct a second dataset based on the main sample described before. Here, we make two adjustments. First, we extend the sample by adding observations for the years 2011–2015. More specifically, we add data for firms observed anytime between 2006 and 2010. As a second adjustment, we only consider firms that are very likely to face financing constraints during the recession (i.e., in 2009) to align the data to assess the recovery of financially constrained firms.⁵ This subsample consists of 4203 firms, corresponding to 50,362 firm-year observations for the period 2006–2015.

2.2 Descriptives

Descriptive statistics on several financial items in Table 1 provide the first insights on key differences among SMEs and large firms by comparing basic balance sheet characteristics across firms. In Panel A, several factors

³ Due to significant confidentiality restrictions, it has proven impossible for us to link the firm-level data with bank-level information, such that the supply-side variables will be based on firms' balance sheet information.

⁴ Indeed, about two-thirds of the firms with less than five employees in the raw data do not hold any bank loans. Excluding these firms implies that our sample does not comprise many startups but rather well-established SMEs. We reflect on this characteristic in our empirical analysis and the discussion section.

⁵ In particular, we consider both SMEs and large firms that have at least a 75% chance of being financially constrained, according to our disequilibrium estimations in Section 3.

Table 1 Descriptive statistics by firm size category (SMEs vs large firms)

Panel A: Comparing basic firm characteristics

| | All | SME | Large |
|----------------------|-------|-------|--------|
| Bank- loan ratio | 0.222 | 0.234 | 0.189 |
| Borrowing diversity | 0.372 | 0.385 | 0.333 |
| Profitability | 2.358 | 2.536 | 1.835 |
| Internal funds | 0.094 | 0.103 | 0.069 |
| Capital expenditures | 0.054 | 0.053 | 0.057 |
| Acc. receivables | 0.296 | 0.301 | 0.283 |
| Collateral | 0.308 | 0.281 | 0.386 |
| Firm size | 9.284 | 8.454 | 11.725 |
| Public (in %) | 7.21 | 2.80 | 20.19 |
| Bonds (in %) | 3.15 | 1.03 | 9.39 |

Panel B: Composition of the liability side

| Category | All | SME | Large |
|------------------------|-------|-------|-------|
| Bank debt | 0.298 | 0.308 | 0.268 |
| Bank debt (short-term) | 0.160 | 0.173 | 0.121 |
| Bank debt (long-term) | 0.138 | 0.135 | 0.147 |
| Trade credit | 0.209 | 0.211 | 0.201 |
| Bonds | 0.004 | 0.002 | 0.012 |
| Nonbank credit | 0.183 | 0.189 | 0.165 |
| Provisions | 0.183 | 0.163 | 0.242 |
| Other liabilities | 0.123 | 0.127 | 0.112 |
| Total | 1.000 | 1.000 | 1.000 |

Notes: This table shows mean values of several financial variables in the main sample, displaying values for all firms, SMEs, and large firms in Columns I–III, respectively. All variables are defined in Panels A and B of Table 4 (Appendix 1). In this table, Panel A displays characteristics derived from balance sheet items. Panel B shows the average composition of the liability side of sample firms' balance sheets. All variables are defined as the balance sheet positions taken from Bundesbank (see Panel A Table 4) as a fraction of total liabilities. Unless indicated otherwise, liability items are aggregated including both short- and long-termed liabilities. Please note that data protection concerns prohibit to display more granular descriptive statistics (e.g., on min max values). Data source: Research Data and Service Centre of the Deutsche Bundesbank (DOI: 10.12757/Bbk.Ustan.8719.05.04), Microdatabase USTAN 2006–2015, own calculations

indicate that the average small firm is more dependent on bank debt than its large counterparts. For example, small firms hold higher levels of bank debt, are less likely to be active on capital or bond markets, and have an overall higher concentration on fewer debt sources, as indicated by the borrowing diversity score.⁶ Further, several characteristics indicate that SMEs are likely to be riskier borrowers than large firms. The level of risk can be inferred from slightly higher levels of accounts

receivable (as an indicator for the ability to collect payments), lower availability of collateral (as measured by tangible assets), which is reflected in higher operating risk, and lower holdings of tangible assets (i.e., potential collateral). All differences mentioned above are statistically significant at the 1% level, as (unreported) *t*-tests show. Regarding financing needs, descriptives show similar capital expenditure levels among SMEs and large firms. These statistics indicate that small firms are typically on a different stage of the firm life cycle, which is confirmed by the differences in the mean age and higher growth rates, i.e., profitability rates. All differences are statistically significant at the 1% level (unreported).

⁶ We compute this index, following (Tengulov, 2019) which measures the concentration of different debt types. Larger values reflect a higher dispersion in debt sources and, thus, a higher concentration on fewer financing sources. Table 4 (Appendix 1) lists and defines all variables.

In Panel B, we take a closer look at the composition of the liability side of firms' balance sheets, using liability ratios of different balance sheet items. We observe smaller firms to have a much higher short-term borrowing (17.3 versus 12.1% of liabilities), whereas larger firms obtain more long-term debt. Overall, however, the share of total bank debt is higher for small firms. Moreover, a much lower fraction of bonds resembles the quasi-absence of small firms in those markets. These stylized descriptives mirror the limited number of financing sources and stronger dependence on bank financing of small firms, as proposed in previous literature (e.g., Faulkender and Petersen 2006). Especially when considered in combination with the characteristics displayed in Panel A, statistics from Panel B illustrate why smaller firms are commonly assumed to be more dependent on bank financing and, thus, more vulnerable to exogenous shocks in the loan supply.

2.3 Institutional background: the financial crisis in Germany

In the following, we outline the institutional context of our empirical analyses. Shortly after the financial crisis shocked financial markets in the US at the end of September 2008, it spilled over to the European financial sector. Because of the global involvement of German financial institutions in the global credit market, the German financial and credit system began to falter, eventually forcing the state to launch a 500 billion Euros rescue program for the financial industry in October 2008. Subsequently, demand for German industrial products and international financial markets collapsed massively, slowing GDP growth to 1.0% in 2008 and a slumping -5.7% in 2009. However, business expectations recovered from an all-time low, indicating a positive outlook by the first quarter of 2010 (Ifo Institute 2019).

An important aspect of our analysis is the effect of the Financial Crisis on bank lending in Germany. Figure 1 illustrates the perceived bank lending conditions at the time by plotting the firm size-specific Ifo Credit Constraint Indicator (Ifo Institute, 2019). The graph documents the fraction of firms perceiving the current willingness of banks to extend credit as restrictive. During the periods of 2005 until 2008 and 2011 until 2012, the perceived degree of being financially constrained among all firms was at a relatively low level

of 20% overall but more than doubled in 2009.⁷ In line with common perceptions on financing constraints of small firms (e.g., Berger and Udell 2006), before 2009, small- and medium-sized firms were reportedly more constrained than larger firms. More importantly, however, the increase in perceived credit constraints at the outbreak of the Financial Crisis in 2009 is most substantial for *large* firms, despite the higher initial values of the other two size categories. These observations contrast the common perception that smaller firms are hit particularly strongly by adverse economic effects (e.g., Holmström and Tirole 1997; Eggers 2020). Further, these observations raise the question of whether small German firms were indeed disproportionately affected by the Financial Crisis and—if not—how did they fend off the adverse economic shock?

3 Methodology

3.1 Considerations on financing constraints

Financing constraints are typically not observable, but several measurement approaches exist. Most measures consider firm size qua definition or are only available for public firms. This is problematic for our analysis because we examine firms of different size categories, including mostly private small firms, as outlined in Section 2.2. Another key challenge for estimating financing constraints is disentangling supply and demand effects. To solve these two aspects, we deploy a disequilibrium method as implemented, e.g., in Kremp and Sevestre (2013), Carbo-Valverde et al. (2016), and described in Karapanagiotis (2024). This approach is advantageous for several reasons. First, integral to our research question, it does not classify small firms as constrained per se, and it can be estimated for any firm. Second, unlike studies that explore information on loan applications via credit registries (e.g., Cantú et al. 2022), this approach allows analyzing demand effects, including information on discouraged borrowers (i.e., those who did not apply for loans). Third, our approach does not rely on survey data to delineate demand and supply factors (as in Presbitero et al. (2014)). However, surveys typically rely on specific selections and may not include sufficient financial data.

⁷ To illustrate that this observation is not source-specific, Fig. 7 (Appendix 2) displays an alternative descriptive statistic from the Deutsche Bundesbank's bank lending survey.

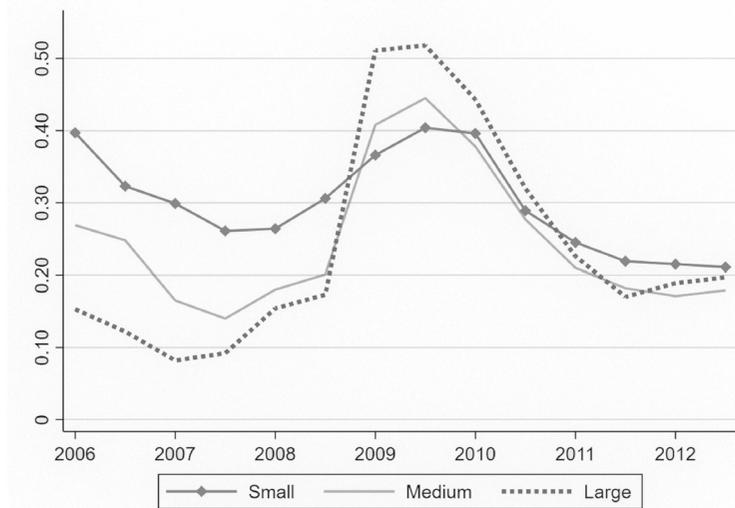


Fig. 1 The Financial Crisis in Germany: Financing climate between 2006 and 2012. *Notes:* The figure graphically illustrates the responses to the Ifo Credit Constraint Indicator for manufacturing firms. To calculate the intensity of credit constraints, firms are asked to answer the question: “How would you assess

the current willingness of banks to extend credit to businesses?” Respondents choose between the answers “accommodating,” “normal,” and “restrictive.” Own illustration based on data from (Ifo Institute, 2019)

The disequilibrium model avoids these caveats by estimating credit demand and supply based on firm-level financial data. Moreover, it provides us with a continuous measure of the intensity of financing constraints expressed as the probability of a firm experiencing excess demand or supply.⁸ Hence, our approach conceptually distinguishes demanded and supplied quantities (Q^d and Q^s), described in the following linear system:

$$\begin{aligned} Q_{it}^d &= (X_{it}^d)' \beta^d + X_{it}' \alpha^d + \varepsilon_{it}^d, \\ Q_{it}^s &= (X_{it}^s)' \beta^s + X_{it}' \alpha^s + \varepsilon_{it}^s, \end{aligned} \tag{1}$$

of firm i at time t , where X_{it}^k (for all $k \in \{d, s\}$) denotes vectors of explanatory variables in the demand and the supply equations. The X_{it} is a vector of common controls in the two equations. The shocks are assumed to be

⁸ Temporary deviations that lead to excess demand or supply in the loan market can be caused by costly information gathering and processing and by the menu costs of banks (Mackowiak & Wiederholt, 2009; Mankiw & Reis, 2002) As such, information asymmetries impede a proper assessment of whether changes in the demand for loans are temporary, idiosyncratic, or uniform to the whole market. Moreover, menu costs induce banks to define a target retail rate as a function of long-term market interest rates.

bivariate normally distributed with $\varepsilon_{it}^d \sim \mathcal{N}(0, (\sigma^d)^2)$, $\varepsilon_{it}^s \sim \mathcal{N}(0, (\sigma^s)^2)$, and where the correlation of ε_{it}^d and ε_{it}^s is ρ (which we might set equal to zero). Our approach combines the equations of the system Eq. 1 with the following condition:

$$Q_{it} = \min\{Q_{it}^d, Q_{it}^s\}, \tag{2}$$

where Q_{it} is the observed amount of loans that resembles the minimum of demanded or supplied loans. This expression implies that the observed quantity belongs either to the demand side or the supply side in Eq. 1. Since this fact cannot be directly observed, the model uses a log-likelihood method to predict hypothetical quantities for both demand and supply (\hat{Q}_{it}^d and \hat{Q}_{it}^s). In other words, the log-likelihood method where Eqs. 1 and 2 are estimated simultaneously gives for each observation in our panel data, a probability whether it belongs to Q^d or Q^s .

Based on the output of these estimations, we construct two measures for the intensity of financing constraints. For the first measure, we start with the follow-

ing expression:

$$\theta_{it} = \frac{\hat{Q}_{it}^d - \hat{Q}_{it}^s}{\sqrt{\hat{\sigma}_d^2 + \hat{\sigma}_s^2 - 2\hat{\sigma}_d\hat{\sigma}_s\hat{\rho}}}. \quad (3)$$

The θ_{it} is the expected excess demand of firm i in period t . In other words, θ_{it} is a non-binary measure of the intensity of financing constraints, which we normalize by the standard deviation of the difference of the demand and supply shocks estimate for all observations in the sample. With this expression at hand, we then calculated the probability of resembling a financially constrained firm in a given year for each observation following Maddala and Nelson (1974, Eq. 2.2). The probability of an observation representing a financially constrained firm is equal to the probability of the firm being in an excess demand regime (with Φ denoting the standard normal distribution), i.e.,

$$\hat{\pi}_{it}^d = P(Q_{it}^d > Q_{it}^s) = \Phi(\theta_{it}). \quad (4)$$

Our second measure specifies a statistic value of excess demand by the difference between expected excess demand and supply relative to the expected supply for loans. This measure captures the extent of excess demand, i.e.,

$$\mathcal{F}_{it} = \frac{\hat{Q}_{it}^d - \hat{Q}_{it}^s}{\hat{Q}_{it}^s}. \quad (5)$$

In \mathcal{F}_{it} , the estimated excess demand is normalized by expected supply, which is observation-dependent and, thus, idiosyncratic. Just like θ_{it} , \mathcal{F}_{it} is independent of the unit of measurement. By regressing \mathcal{F}_{it} on a set of independent variables, we can investigate whether size characteristics are indeed relevant in explaining a potential increase in financing constraints throughout the financial crisis.

3.2 Variable specifications and estimation results of the disequilibrium model

As the main dependent variable, Q_{it} , we specify firms' bank-loan ratios as the end-of-the-period total amount of loans owed to credit institutions as a fraction of total assets. In the following, we define determinants for the demand and supply of loans. To allow for identification,

we have to make a qualified selection of variables in each of the two equations, i.e., imposing an exclusion restriction (see, e.g., Carbo-Valverde et al. 2016). Table 4 (Appendix 1) contains an overview of all variables of our empirical model.

Demand for bank financing is particularly affected by its price and the availability of other, less expensive substitutes because external debt financing is a relatively costly funding option (Love et al., 2007; Myers & Majluf, 1984). We, therefore, model loan demand as a function of the *interest rate* and financing alternatives.⁹ For the financing alternatives, we consider firms' *internal funding* via cash flows. Further, we consider firms' *capital expenditures* as a more direct measure of firms' (long-term) financing needs. Moreover, firms with diversified debt structures are less vulnerable to economic slowdowns (Giannetti, 2019), which is why we incorporate a measure of firms' *borrowing diversity*.

The supply-side determinants relate to default costs expressed as the risk associated with the potential borrower (Freixas & Rochet, 2008). We thus follow related studies, such as (Kremp & Sevestre, 2013), and consider three variables that reflect less risky and less volatile cash flows, all of which should translate to a higher willingness of banks to supply loans: (i) the share of *accounts receivable* to total assets as an indicator of firms' ability to collect payments on their business activities (i.e., lower liquidity risk), (ii) the availability of *collateral* as measured by firms' stock of tangible assets, and (iii) *profitability*, as measured by the returns to assets.¹⁰

Further, we acknowledge that several covariates affect loan demand and supply simultaneously. First, *firm size* helps to control for the firm-specific risk and the need for bank debt, thereby addressing both loan demand and supply factors. Second, controlling for time fixed effects (*year-fe*) is important because it allows, among others, to control for the refinanc-

⁹ We impute a hypothetical interest rate for firms with zero loans using a coarsened exact matching (CEM) procedure for observations without outstanding bank loans. This applies to 24% of our sample firms. Appendix 3 elaborates on this in detail. For robustness, our analyses contain results for firms with and without imputed interest rates.

¹⁰ Further, our specification incorporates the fact that banks set prices according to borrowers' risk and not demanded quantities, i.e., banks first decide how much they are willing to lend before they set interest rates (Kremp & Sevestre, 2013). We follow this consideration and do not include interest rates as a supply-side determinant for lending.

ing costs of banks with the European Central Bank and business cycle-specific fluctuations in the need for funding. Third, the heterogeneity in loan demand and supply is also dependent on possible industry-specific features, which we control for by including time-invariant, industry fixed effects (*industry-fe*). Similarly, banks restrict lending in times of economic contractions independently of interest rates such that credit rationing may occur irrespective of firms' willingness to pay high interest rates (e.g., Stiglitz and Weiss 1981; Nilsen 2002). Moreover, applying these fixed effects accounts for important determinants of banks' lending decisions at the extensive and intensive margin. As such, banks often specialize in lending to different industries (De Jonghe et al., 2020; Paravisini et al., 2023), and the supply of loans follows political and economic cyclical patterns (Becker & Ivashina, 2014), which we aim to capture by including industry and year fixed effects. Moreover, firm size directly relates to the costs of banks to provide loans as regulatory requirements stipulate capital requirements depending on firm sizes (e.g., Heid 2007). Hence, our model captures important supply-side factors even without explicitly including bank-level supply-side determinants.

Formally, we can summarize the above such that the vectors in Eq. 1 are defined as follows:

$$\begin{aligned} X_{it}^d &= \{interest\ rate, borrowing\ diversity, internal\ funds, capital\ expenditures\}, \\ X_{it}^s &= \{acc.\ receivables, collateral, profitability\}, \\ X_{it} &= \{firm\ size, year-fe, industry-fe\}. \end{aligned} \tag{6}$$

Table 2 provides the parameter estimates of our disequilibrium analysis for different model specifications, using the years 2006–2010 (i.e., crisis and non-crisis periods). We display our main specification in Column I, following the setup described above. All parameters have the expected signs. For example, starting with the interest rate, we see that a 1-percentage point increase in the interest rate is associated with a decrease in the demand by 0.0055. Holding this coefficient together with the mean value reported in Table 1 (0.222) resembles a 2.5% drop in loan demand. This magnitude is comparable to what other studies already discussed have found (e.g., Kremp and Sevestre 2013). Moreover, in this general setup, the firm size is an important determinant for the demand and supply of bank

loans, e.g., loan supply relating negatively to firm size and smaller firms demanding more bank-credit. On the demand side, small firms are more likely to be in a growth phase, which raises their need to leverage business operations with external debt. When filing for a bank loan, however, larger firms are more likely to seek more funds per contract. *Ceteris paribus*, this may indicate that loans to small firms are attractive for banks because serving a large loan contract occupies a larger share of the available reserves, reducing banks' lending diversification, while they can demand higher interest rates from smaller firms. Estimates on the time-dummy report a strong aggregate decrease in demanded and supplied loans beginning in 2009. The effect is larger for the supply (−0.0229) than for the demand (−0.0094). This observation also applies to 2010 and confirms the descriptive statistics.

These results are robust to a variety of tests, such as imposing independence of the error terms (Column II), adding Mundlak fixed effects (Mundlak, 1978), and, in the spirit of Kremp and Sevestre (2013), lagged dependent variables (Column III). None of these adjustments significantly changes our findings, mitigating concerns regarding the exact model specification. For further robustness tests, we repeat this analysis, excluding firms with zero loans. Table 7 (Appendix 1) summa-

rizes these findings and shows no major differences in the estimations. Further, consistent with our approach to using one model for the entire time frame, Table 8 (Appendix 1) indicates qualitatively similar estimates across subsamples of firms and time.

4 Excess demand for bank loans—empirical analysis

4.1 Probability of excess demand for bank loans

Based on the estimation results of the disequilibrium model presented, we construct the two financial constraint measures presented earlier. We begin our anal-

Table 2 Disequilibrium model estimation results

| Dependent variable: | Bank-loan ratio Demand equation | | | Supply equation | | |
|-----------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| | (Ia) | (IIa) | (IIIa) | (Ib) | (IIb) | (IIIb) |
| Interest rate | −0.555 ^{***} (0.0095) | −0.6092 ^{***} (0.0116) | −0.3514 ^{***} (0.0448) | | | |
| Borrowing diversity | 0.8194 ^{***} (0.0093) | 1.0879 ^{***} (0.0091) | 1.2403 ^{***} (0.0370) | | | |
| Internal funds | −0.2383 ^{***} (0.0089) | −0.2798 ^{***} (0.0111) | −0.5222 ^{***} (0.0195) | | | |
| Capital expenditures | 0.0838 ^{***} (0.0082) | 0.0248 ^{**} (0.0103) | 0.2339 ^{***} (0.0206) | | | |
| Firm size | −0.0148 ^{***} (0.0004) | −0.0168 ^{***} (0.0005) | −0.0180 ^{***} (0.0012) | −0.0089 ^{***} (0.0006) | −0.0102 ^{***} (0.0006) | −0.0010 ^{***} (0.0002) |
| Acc. receivables | | | | −0.1750 ^{***} (0.0060) | −0.1796 ^{***} (0.0056) | 0.0021 (0.0021) |
| Collateral | | | | 0.3218 ^{***} (0.0059) | 0.2766 ^{***} (0.0053) | 0.0136 ^{***} (0.0020) |
| Profitability | | | | −0.0101 ^{***} (0.0008) | −0.0099 ^{***} (0.0007) | −0.0027 ^{***} (0.0008) |
| Year: 2007 | 0.0067 ^{***} (0.0021) | 0.0073 ^{***} (0.0028) | 0.0053 (0.0056) | 0.0001 (0.0032) | 0.0003 (0.0030) | 0.0083 ^{***} (0.0016) |
| Year: 2008 | 0.0024 (0.0021) | 0.0016 (0.0028) | −0.0059 (0.0055) | −0.0025 (0.0031) | −0.0017 (0.0030) | 0.0088 ^{***} (0.0015) |
| Year: 2009 | −0.0094 ^{***} (0.0022) | −0.0105 ^{***} (0.0029) | −0.017 ^{***} (0.0055) | −0.0229 ^{***} (0.0031) | −0.0204 ^{***} (0.0030) | −0.0035 ^{***} (0.0011) |
| Year: 2010 | −0.0113 ^{***} (0.0021) | −0.0126 ^{***} (0.0029) | −0.0145 ^{***} (0.0056) | −0.0252 ^{***} (0.0032) | −0.0238 ^{***} (0.0031) | −0.0064 ^{***} (0.0012) |
| Sigma (D/S) | 0.0089 ^{***} (0.0002) | 0.0080 ^{***} (0.0001) | 0.0194 ^{***} (0.0009) | 0.0516 ^{***} (0.0004) | 0.0507 ^{***} (0.0004) | 0.0065 ^{***} (0.0000) |
| Rho | 0.7790 ^{***} (0.0150) | - - | −0.3296 ^{***} (0.0221) | 0.7790 ^{***} (0.0150) | - - | −0.3296 ^{***} (0.0221) |
| D–S relation: | Correlated | Independent | Correlated | Correlated | Independent | Correlated |
| <i>Additional controls:</i> | | | | | | |
| Industry-FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Mundlak correction | No | No | Yes | No | No | Yes |
| Lagged dep. variable | No | No | Yes | No | No | Yes |

Notes: This table displays the main regression results from the disequilibrium model explaining bank-loan-to-asset ratios. Demand and supply determinants are defined as specified above. In Column II, error terms are uncorrelated, in Column III we introduce additional Mundlak dummies, i.e., firm-specific time-invariant mean values of the independent regressors based on the three years before the sample (2003–2005) and the lagged dependent variable on both the demand and the supply sides. All regressions control for industry fixed effects, which are omitted in the output. Standard errors are displayed in parentheses below the coefficients. Asterisk symbols *, **, and *** denote significance at the 10, 5, and 1% levels, respectively. Data source: Research Data and Service Centre of the Deutsche Bundesbank (DOI: 10.12757/Bbk.Ustan.8719.05.04), Microdatabase USTAN 2006–2015, own calculations

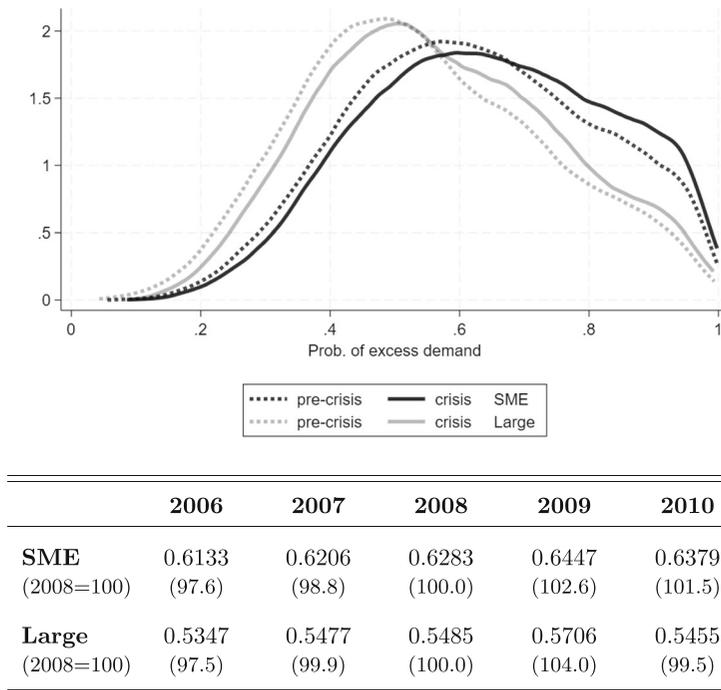


Fig. 2 Probability of expected excess demand, $\hat{\pi}_{it}^d$: Kernel density SMEs versus large firms. *Notes:* These figures illustrate estimation results on observations representing a financially constrained firm, i.e., being the excess demand regime as defined in Eq. 4. Panel A plots the kernel density distributions for SMEs (red) and large firms (blue), both during economic upswings and recessions, i.e., comparing the sample precrisis years 2006–2008 (dashed lines) with the crisis year 2009 (solid lines). The corresponding mean values of the probability of a firm experiencing excess demand for bank loans are displayed below the graph. The

probability is displayed for SMEs and large firms as well as for each year of the sample period separately. Panel B displays firms’ average probability of being financially constrained as specified in Eq. 4 for the years 2006–2010 and distinguishes between SMEs and large firms. The line corresponds to the unweighted averages among these subgroups indexed (=100) by their 2008 value. Data source: Research Data and Service Centre of the Deutsche Bundesbank (DOI: 10.12757/Bbk.Ustan.8719.05.04), Microdatabase USTAN 2006-2015, own calculations

ysis by investigating the relative changes in the probability distributions of financing constraints, comparing SMEs and large firms over the course of the Global Financial Crisis. Figure 2 summarizes the main findings. Specifically, we display our estimations of $\hat{\pi}_{it}^d$ from Eq. 4. Panel A maps the distributions of our calculated probabilities (i.e., the degree) of financial constraints for financially constrained SMEs and large firms during years of—broadly speaking—economic growth (2006–2008) and recessions (2009–2010).¹¹ There are three main observations to this. First, the distributions for SMEs and large firms shift right during crisis years, reflecting a tightening in constraints.

These shifts imply that the average probability of an observation representing a financially constrained firm increases for SMEs and large firms. Second, SMEs have, on average, a higher probability of experiencing a situation of excess demand, irrespective of the particular time period. Before and during the crisis, the mode of the SME distributions indicates higher average values relative to the distributions for large firms. These two findings corroborate previous literature and common priors on financially constrained firms (e.g., Taketa and Udell 2007; Kahle and Stulz 2013).

As a third observation, we find the relative increase in the share of financially constrained firms to be disproportionately larger for SMEs than for large firms. The mean values of $\hat{\pi}^d$ for each year between 2006 and 2010 are displayed below the graph. In absolute terms and

¹¹ Panel A of Fig. 8 (Appendix 2) plots the distributions of this measure for all sample years separately.

comparing 2008 and 2009 values, the average probability increases by 1.6 percentage points for SMEs and 2.2 percentage points for large firms. However, these differences are statistically not significant. For illustration, we display the year-to-year development of financing constraints by indexing 2008 values (=100) of financing constraints in Fig. 2, showing that the increase is at the same order of magnitude for SMEs and large firms in relative and absolute terms. As a robustness test, we can further show that survivorship biases are unlikely to confound our results (see, e.g., Fig. 8B in Appendix 2). We also find that SMEs did disproportionately suffer from the Great Financial Crisis in terms of insolvencies when considering basic sample descriptives: The share of SMEs even slightly increased from 97.9% in 2008 to 98.1% in 2010. Overall, these aspects show that SMEs are generally more constrained than large firms, but they do not support the view that financing constraints disproportionately tightened for SMEs.

4.2 Determinants of excess demand for bank loans

As a next step, we utilize the continuous measure of financing constraints, i.e., values of excess demand (\mathcal{F}_{it}) as defined in Eq. 5, to examine the importance of its individual components. Table 3 displays the corresponding estimates of a set of fixed effects regressions using excess demand (\mathcal{F}_{it}) as the dependent variable. In Column I, we use the full sample and deploy all main elements of the disequilibrium model as regressors. The estimates confirm our priors: the interest rate, alternative funding resources, and available collateral relate negatively to estimated excess demand, i.e., financing constraints. The riskiness of firms and their financing needs are positively associated with estimated excess demand. These findings are statistically significant at the 1% level. Remarkably, firm size is one distinct parameter that does not explain variation in estimated excess demand, conditional on the other excess demand determinants. Here, the coefficient on firm size captures variation across all firms. These findings suggest that firm size is relatively less important compared to other components in explaining firms' level of excess demand.

We then split the sample into pre-crisis (Column II) and crisis (Column III) years to explore whether these observations change when considering different macroeconomic situations. In general, coefficients

vary only slightly in magnitude. For example, financing needs appear more important in determining the probability of financing constraints during the crisis years (9.457) as compared with before (8.616). The firm size measure is again the only notable exception. For the years of economic upswing (2006–2008), the firm size coefficient is statistically significant at the 10% level and negative (−1.308). In other words, under good macroeconomic conditions, smaller firms are more likely to face excess demand than large firms and, hence, are more financially constrained. However, this changes when considering the crisis years. We find a statistically significant, positive effect (2.583) for firm size for 2009 and 2010. Everything else being equal, this implies that small firms are not more likely to be in an excess demand setting during the period of the Global Financial Crisis.

These findings are robust to several additional tests. First, Column IV of Table 3 repeats the initial specification but adds an interaction term, $SME \times Crisis$, capturing the additional effect of SMEs during times of crisis (i.e., a dummy equal to one for the years 2009 and 2010) on the probability of excess demand. Confirming the above results, we find a negative significant coefficient suggesting that financing constraints tighten disproportionately less for SMEs than for larger firms during the crisis. Second, to detail on the effects of firm size, Table 9 (Appendix 1) contains a set of different estimation specifications that are similar to those in Column IV. Only here, we deploy different size categories (i.e., distinguishing medium-sized, small, and micro firms) instead of the simple SME-dummy. The results show that the negative associations of firm size and financing constraints apply to medium-sized and small firms (Columns I and II in Table 9). For micro firms, the coefficients are negative but statistically insignificant (Columns III and IV in Table 9).¹² Moreover, we do not find significant differences when considering the size-related effects *within* the category of SMEs (Columns V and VII in Table 9). Third, we test the additional role of firm age in this context. To this end, Column V of Table 3 repeats the previous specification but adds controls for firm age. The coefficients on age and age-square are statistically insignificant and including these controls does not qualitatively affect the findings. Similarly, the results in Columns IV and

¹² Arguably, the lack of significance may be due to the small number of micro-sized firms in the sample (see Table 5).

Table 3 Regression estimates: excess demand determinants before and during the crisis

| Dependent variable | Excess demand (\mathcal{F}_{it}) | | | | |
|------------------------|--------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | (I) | (II) | (III) | (IV) | (V) |
| Interest rate | -60.504*** (0.251) | -60.161*** (0.337) | -60.424*** (0.546) | -60.507*** (0.251) | -60.529*** (0.251) |
| Borrowing diversity | 78.095*** (0.269) | 78.643*** (0.353) | 76.920*** (0.465) | 78.110*** (0.269) | 78.103*** (0.269) |
| Internal funds | -24.403*** (0.253) | -24.611*** (0.392) | -24.691*** (0.510) | -24.433*** (0.253) | -24.426*** (0.253) |
| Capital expenditures | 8.556*** (0.191) | 8.616*** (0.245) | 9.457*** (0.453) | 8.564*** (0.190) | 8.565*** (0.191) |
| Firm size | 0.198 (0.554) | -1.308* (0.679) | 2.583* (1.390) | 0.473 (0.561) | 0.523 (0.563) |
| Firm size ² | -0.055** (0.028) | 0.036 (0.035) | -0.188*** (0.068) | -0.071** (0.028) | -0.074** (0.028) |
| Acc. receivables | 16.260*** (0.290) | 16.447*** (0.420) | 16.636*** (0.518) | 16.242*** (0.290) | 16.238*** (0.290) |
| Collateral | -32.703*** (0.277) | -32.877*** (0.378) | -32.583*** (0.571) | -32.730*** (0.277) | -32.724*** (0.277) |
| Profitability | 0.996*** (0.042) | 1.027*** (0.058) | 1.004*** (0.100) | 1.000*** (0.042) | 1.000*** (0.042) |
| Firm age | | | | | -0.033 (0.024) |
| Firm age ² | | | | | -0.0001 (0.0003) |
| SME × Crisis | | | | -0.295*** (0.045) | -0.284*** (0.046) |
| Constant | 45.702*** (2.762) | 50.908*** (3.390) | 36.269*** (7.142) | 44.663*** (2.786) | 45.301*** (2.818) |

Table 3 continued

| Dependent variable | Excess demand (\mathcal{F}_{it}) | | | | |
|----------------------|--------------------------------------|---------------------------|-----------------------|--------|--------|
| | (I) | (II) | (III) | (IV) | (V) |
| Sample years: | All | Pre-crisis (2006–2008) | Crisis (2009–2010) | All | |
| Additional controls: | | | | | |
| Firm-FE | Yes | Yes | Yes | Yes | Yes |
| Year-FE | Yes | Yes | Yes | Yes | Yes |
| Observations | 73,461 | 42,702 | 27,820 | 73,461 | 73,461 |

Notes: This table displays regression results on a set of fixed effects panel regressions explaining estimated excess demand as a dependent variable as defined in Eq. 5. For readability, excess demand is expressed in percentage points. All specifications include firm and year fixed effects. Columns I, IV, and V use the full sample, whereas Columns II and III only use the pre-crisis years of 2006–2008 and the crisis years 2009–2010, respectively. Standard errors are clustered on the firm level and displayed in parentheses below the coefficients. Asterisk symbols *, **, and *** denote significance at the 10, 5, and 1% levels. Data source: Research Data and Service Centre of the Deutsche Bundesbank (DOI: 10.12757/Bbk.Ustan.8719.05.04), Microdatabase USTAN 2006–2015, own calculations

V of Table 3 are not sensitive to excluding very young firms from the sample (see Columns VIII and IX in Table 9, Appendix 1). Our main effects can thus be mostly attributed to established SMEs, reflecting the relevance of bank debt as a prime source of external financing for them—but not for young startups. Overall, these results provide robust evidence suggesting that firm size is not the main determinant of financing issues during recessions. Instead, it is rather a combination of underlying factors that explain differences in excess demand across firms and time.

4.3 Implications of increased financing constraints

So far, our estimates indicate that it is not SMEs per se that are affected most by the Financial Crisis. We extend our investigation by considering its impact on bank-loan ratios and other (non-bank debt) dimensions throughout the crisis by estimating:

$$Y_{it} = \sum_{S=2007}^{2010} \beta^P (Year_{it}^P) + \phi X_{it} + u_{it}, \quad (7)$$

where $Year^P$ is a binary indicator equal to one for the years P for all [2007, 2010] and X_{it} is a set of firm-level controls used in Section 3.2. The year 2006 serves as a reference year. We estimate the specification separately for the full sample, SMEs, and large firms. As

dependent variables, we use bank-loan ratios as before, and two dimensions that provide insights on alternative financing use, a borrowing diversity index and firms' cash holdings. The coefficient β thus describes the development of these outcomes over time, relative to 2006. This outcome can be equally decomposed to constrained and unconstrained, small or large firms (see in more detail in Section 4.4).

Figure 3 plots the β coefficients from estimating Eq. 7 denoting the movement of respective outcomes relative to the base year 2006. Panel A illustrates the sharp impact of the financial crisis on German firms: Whereas bank-loan ratios remained relatively constant until 2008, they dropped sharply in 2009. This drop is significant both statistically and economically. Controlling for confounding factors, the median firm decreased its bank-loan ratio on average by 8.2% from 2008 to 2009, i.e., by 1.5 percentage points from 18.1 to 16.6%.

Moreover, the analysis also shows how firms respond to the decline in the use of loans. As such, Panel B shows that both types of firms exhibited higher levels of the borrowing diversity index during 2009 than in pre-crisis periods. This observation implies a concentration on fewer debt sources during the crisis and indicates a tightening of external funding across debt categories. Although the effect is larger for SMEs, the overlapping whiskers show that the differences between smaller and larger firms are not statistically significant. Only in 2010, the coefficient for SMEs is still posi-

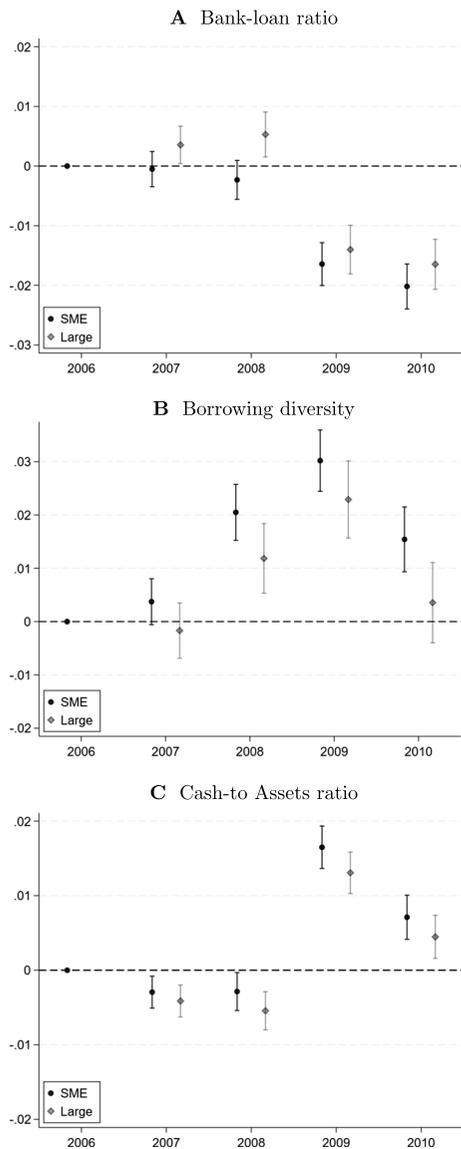


Fig. 3 Short-term adjustments to tightened financing constraints, SMEs vs large firms. *Notes:* The figure plots coefficients of three separate regressions, each of which estimates Eq. 7. Estimations use three different samples: (1) full sample, (2) SMEs, and (3) large firms. The graph plots the respective β coefficients for each of the subsamples. The dependent variables are bank-loan ratios (A), the borrowing diversity index (B), and the cash and cash equivalents to the total asset ratio (C). All variables are defined in Table 4 (Appendix 1). 2006 is the reference year. Whiskers represent 95% confidence intervals. Standard errors are heteroscedasticity-consistent and clustered at the firm level. Data source: Research Data and Service Centre of the Deutsche Bundesbank (DOI: 10.12757/Bbk.Ustan.8719.05.04), Microdatabase USTAN 2006–2015, own calculations

tive and significant, whereas it is insignificant for large firms. Notably, however, the overall development of an increased concentration on fewer debt sources already unfolded in 2008, whereas the crisis mainly affected German firms in 2009. Hence, the concentration on fewer financing sources may also reflect the flexibility of the firms to react early on to the decline in business.¹³

Furthermore, we investigate whether SMEs actually mitigate the adverse shock of the Global Financial Crisis by prudent behavior, i.e., by adjusting their holdings of cash and cash equivalents. Firms, and in particular smaller ones, are found to be more likely to be liquidated when they are in financial distress (Ozkan & Ozkan, 2004), which might induce them to increase cash holdings to avoid financing distress in the first place. This precautionary effect may occur in response to a sudden shock (e.g., Dessaint and Matray 2017). Panel C shows that firms indeed strongly increased cash holdings in 2009. The effect is highly significant and translates roughly to a 20% increase in cash for the median SME. The effect holds for both SMEs and large firms; higher associated costs of financial distress can explain why firms build up cash buffers as a reaction to the overall slowdown in economic activity (Kahle & Stulz, 2013). Moreover, we find that both small and large firms decrease their capital expenditures with the onset of the Financial Crisis in a very similar manner (see Fig. 9B in Appendix 2). Notably, also the impact on capital expenditures appears virtually equivalent for small and large firms. Against the background of our previous results, this suggests that firms substitute external funding by building up cash buffers.

4.4 Longer-termed implications

Whereas our previous analyses focus on the initial impact of the Global Financial Crisis on firms' financial positions, it is reasonable to assume that some effects—including recovery processes—are only visible from a longer-termed perspective. In the following, we extend our analysis by studying the post-crisis

¹³ For example, the data mirror aggregate statistics from the Ifo Business Climate Index, which separately reports business expectations and the current business situation (see Fig. 9A in Appendix 2). Although the current business situation only declined in 2009, expectations already worsened as of the second half of 2008.

period until 2015. More specifically, we focus on those firms identified by the disequilibrium estimations as being financially constrained during the recession year 2009. If financing constraints during crises lead only temporarily to worse performance, these firms should have recovered with the economy recovering as well. Hence, analyzing firms that faced financing constraints in 2009 and distinguishing between SMEs and large firms will provide a more complete picture of the implications of the crisis on these firms.

Therefore, we extend our main sample by adding observations for 2011–2015 as described in Section 2. Again, we consider SMEs and large firms whose probability of being financially constrained as defined in Eq. 5 is equal to or larger than 75%. This way, 4203 individual firms, or 28.1% of all firms in the sample, are flagged as financially constrained in 2009. The fraction of SMEs that classify as constrained (31.0%) is higher than the fraction of large firms (18.7%), which is consistent with our previous analysis, e.g., Fig. 2. Using the extended sample, we estimate the long-term evolution in financing and other economic activities for financially constrained SMEs and large firms by reestimating Eq. 7. Moreover, we use two sets of outcomes as dependent variables that relate to the (a) financing and (b) real economic activities of firms, which are summarized in Figs. 4 and 5, respectively. Similar to before, we plot the yearly coefficients from the event-study-type regressions.

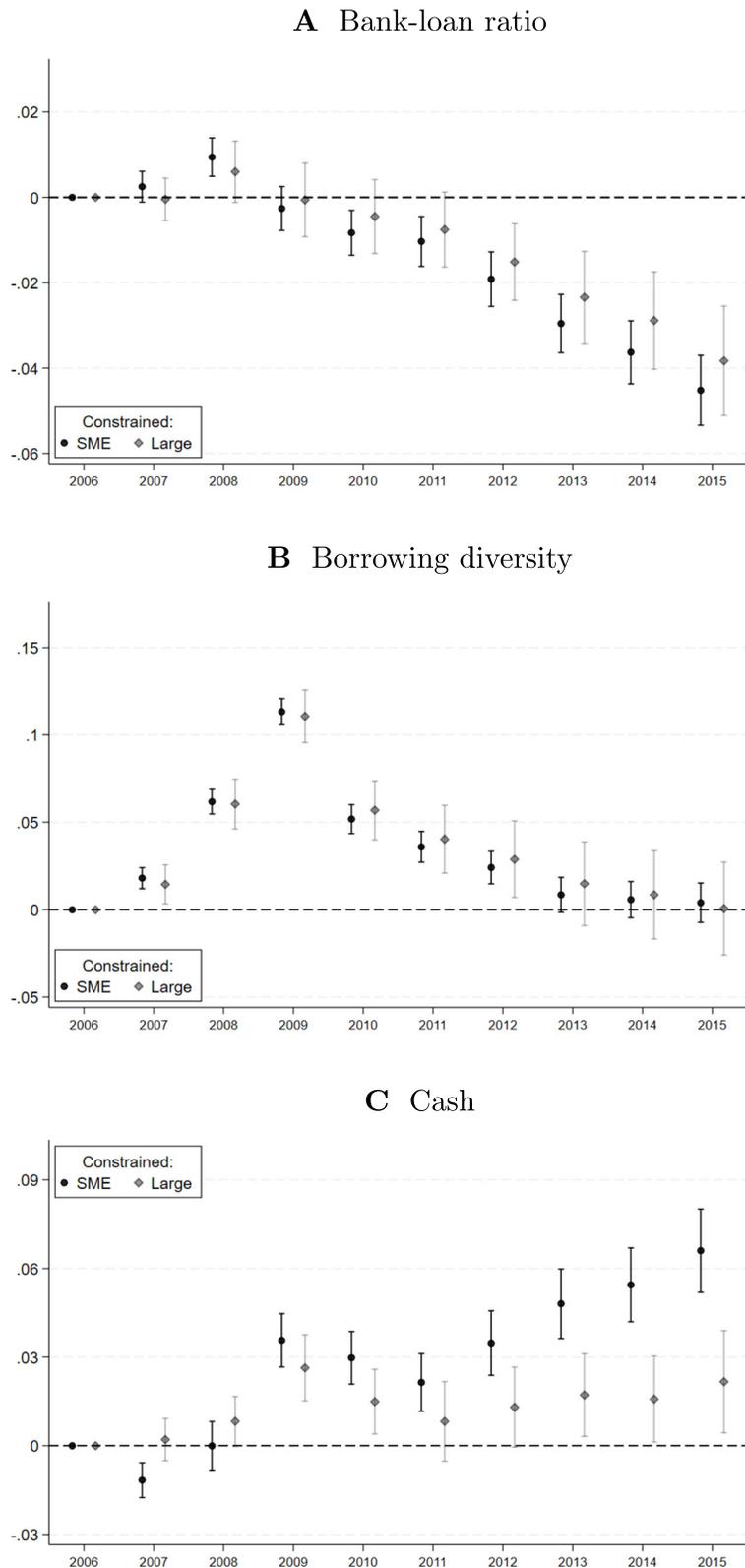
Regarding financial activities, in Fig. 4, we assess three specific outcomes. First, in Panel A, we use firms' bank-loan ratios as the dependent variable and observe the deleveraging trend over the entire extended sample period. This observation is consistent with recent empirical evidence from SMEs in the US that find lower use of debt financing as a persistent long-term trend since the 1980s (e.g., Dell'Ariccia et al. 2021). However, we find no statistically significant difference in this trend between SMEs and large firms, suggesting that the deleveraging applies equally to firm size categories. Second, in Panel B, we investigate borrowing diversity: During the crisis years, firms appear to concentrate increasingly on fewer sources of external financing, including the previously observed anticipatory effect in Section 4.3; at the latest by 2013, firms revert to pre-crisis levels of borrowing diversity. As an important finding, this is again very similar among constrained SMEs and constrained large firms. Consistent

with Giannetti (2019), this finding suggests the crucial role of debt concentration during times of economic distress. Third, in Panel C, we use the cash-to-liability ratio as the dependent variable. SMEs increased their cash holdings with the onset of the crisis in 2009. In the aftermath of the crisis, they initially lowered these amounts slightly but increased cash holdings thereafter. This pattern is different from larger firms: They increased cash holdings in 2009, but unlike smaller firms, large firms reduced these cash holdings by 2011 to pre-crisis levels and maintained those until 2015. These findings suggest that financially constrained German firms respond to crises by building up cash buffers to strengthen their financing position. This observation would be in line with other studies on the response of firms and managers to adjust financing positions in response to adverse shocks (e.g., Kahle and Stulz 2013; Dessaint and Matray 2017). On top of this, SMEs build up these buffers even more persistently. Combining the three findings of sustained deleveraging, an increase in cash holdings, and no change in borrowing diversity in the longer term suggests that firms, and in particular SMEs, potentially substitute cash for debt.

As a next step, we investigate the evolution of financially constrained firms' real economic activities, measured in terms of firm profitability, capital expenditures, and employment. Figure 5 shows a consistent picture across these three dimensions; that is, the average constrained firm exhibits lower levels of real activities during the crisis period.¹⁴ Moreover, both constrained SMEs and large firms in our sample recovered with increased profitability immediately after the crisis in 2011 (Panel A). Similarly, employment rates reverted to precrisis years immediately after the crisis (Panel B). However, some of the longer-term implications differ across firms. As such, Panel C shows differences in the recovery regarding capital expenditures. Constrained SMEs reverted to precrisis levels by 2010. Although this reversal is persistent over time, the level of investment of constrained large firms remains at the lows of the crisis. For robustness, we back all of these obser-

¹⁴ Regarding potential firm failures, we observe that 24.2% of SMEs and 23.7% of large firms active in 2007 dropped out of the sample by 2012. However, the mere fact that firms are still alive does not rule out weak performance. As such, it has been shown that many firms survive crises but remain in a zombie-like state in the aftermath of economic slowdowns (e.g., Acharya et al. 2019).

Fig. 4 Evolution of financing activities by constrained SMEs and large firms (2006–2015). *Notes:* The figure displays the evolution of changes in financing activities differentiating between financially constrained SMEs and constrained large firms. The graphs plot coefficients (β) similar to those on estimations of Eq. 7, only here we use an extended sample, covering the years 2006–2015. The dependent variables are specified as before: Bank-loan ratio (A), borrowing diversity (B), and firms' cash holdings, measured as cash-to-liability ratio (C). The coefficients plotted are for each year, relative to 2007. Whiskers represent 95% confidence intervals. Standard errors are heteroscedasticity-consistent and clustered at the firm level. Data source: Research Data and Service Centre of the Deutsche Bundesbank (DOI: 10.12757/Bbk.Ustan.8719.05.04), Microdatabase USTAN 2006–2015, own calculations



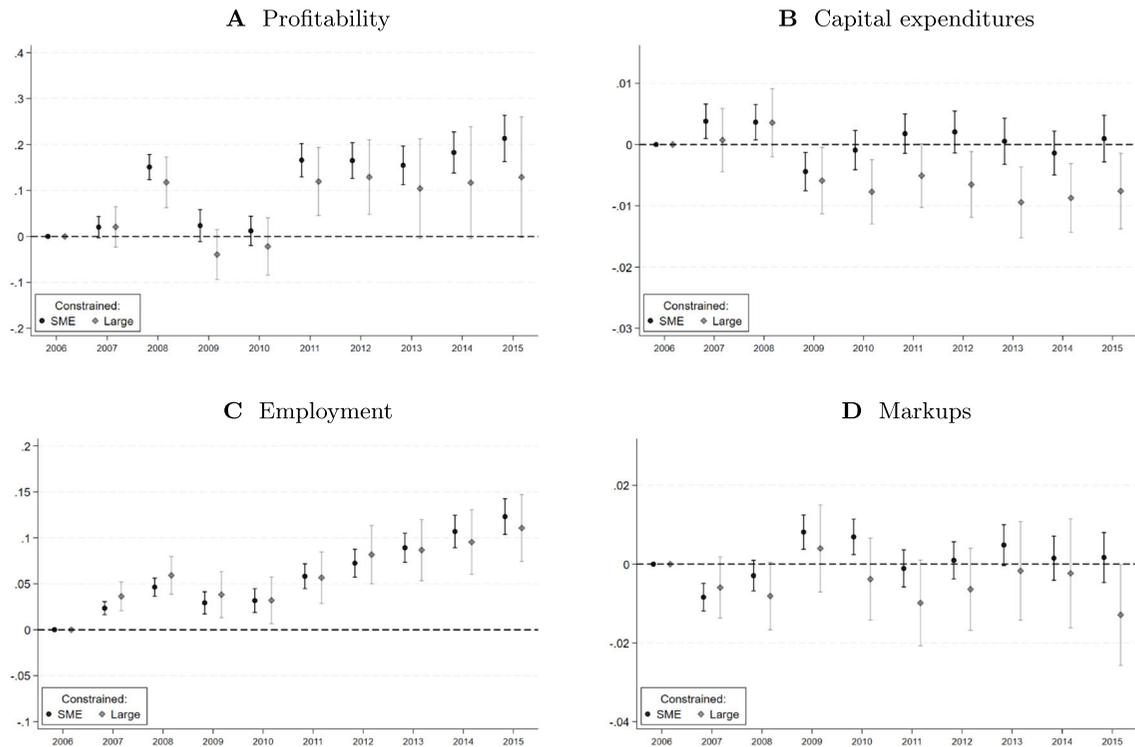


Fig. 5 Long-term impact on real activities of constrained SMEs and large firms (2006–2015). *Notes:* The figure displays the evolution of changes in real economic activities similar to Fig. 4. The dependent variables are profitability measured as EBIT over total assets (A), investment measured as capital expenditures over total assets (B), employment measured using the logarithm of the number of total employees (C), and firm-level markups mea-

sured by dividing total operating income by operating expenses (D). The coefficients plotted are for each year, relative to 2007. Whiskers represent 95% confidence intervals. Standard errors are heteroscedasticity-consistent and clustered at the firm level. Data source: Research Data and Service Centre of the Deutsche Bundesbank, Microdatabase USTAN 2006–2015, own calculations

variations by testing alternative specifications of the measures for profitability, growth, and capital expenditures (see Fig. 10 in Appendix 2). Summarized, constrained SMEs and large firms appear to respond similarly at the onset of the crisis, a pattern confirming aggregate statistics introduced in Section 2. On top of this, we find recovery patterns to be comparable. If anything, the recovery of SMEs is stronger, in particular regarding investment rates in the form of capital expenditures.

As a final step, we also investigate changes in the markups of respective firms. According to Meinen and Soares (2022), firms that are more exposed to liquidity risks, especially financially constrained firms, tend to raise markups in response to adverse bank-loan supply shocks to sustain liquidity. We measure markups as the

share of income from operating activities over operating expenditures. Figure 5D again plots estimates of β coefficients in estimating Eq. 7, this time using firm-level markups as the dependent variable. Using firm-level markups as a dependent variable shows that SMEs indeed increased markups during 2009 and 2010 while reverting to 2006 levels from 2011 onwards. This pattern is well in line with Meinen and Soares (2022). However, we do not find statistically significant patterns like this for larger firms.

The above evidence strongly suggests that SMEs sustained the negative impact of the Global Financial Crisis by increasing markups, short-term divestment, and a sustained accumulation of cash holdings. Whereas these patterns apply also to larger firms, they

are most pronounced for SMEs. These findings highlight potential mechanisms for how small firms can cope with adverse economic shocks. Moreover, among several measures, we do not detect significant differences in other financing activities or performance- and growth-related outcomes between SMEs and large firms.

5 Discussion

5.1 Contributions and implications

Our analyses provide new insights into a central question in the literature of small business economics: How do small firms cope with changes in their business environment, and to what extent are they capable to sustain adverse economic shocks? The traditional view on the liabilities of smallness posits that smaller firms are resource-constrained, especially in terms of financial assets and skilled personnel (Aldrich & Auster, 1986; Freeman et al., 1983). A common perception is that these liabilities leave small firms more vulnerable to slowdowns in economic activity (see Holmström and Tirole 1997; Faulkender and Petersen 2006; Eggers 2020). Our work corroborates the fact that SMEs were significantly hit by the financial crisis (see, e.g., Udell 2020). Importantly, these effects were not disproportionately more severe for SMEs than for large firms in Germany. Our results also suggest that SMEs dynamically adjust their operations in response to the crisis. In particular, these adjustments include short-term divestment that yields cash accumulation as well as increasing markups.

Our study contributes to empirical and theoretical considerations on the role of small organizations in changing economic environments. In particular, a prominent stream of related literature describes the dynamic organizational capabilities of small businesses (Nicolas, 2022; Raymond & St-Pierre, 2013; Wai et al., 2022). Here, the term *smallness* is not only linked to liabilities but also to capabilities, such as operational flexibility. As such, the organizational structures of small firms are less complex and hierarchical than those of larger peers, implying better abilities to adapt to changing business environments. In this context, existing work often focuses on different forms of technology

adoption (Bruque & Moyano, 2007; Escoz Barragan & Becker, 2024; Hu et al., 2023; Kurnia et al., 2015). In contrast, our analysis contributes to the literature by demonstrating the flexibility of SMEs to adjust operations and their underlying workings during times of economic turbulence. Thereby, we offer a nuanced view on the traditional perspective of the liabilities of smallness as we show different mechanisms for how small firms can navigate through times of economic distress.

These insights have several important practical and policy implications. They contribute to the discussion of how new small firms can overcome resource constraints, especially during turbulent times. Our findings help to gain a better understanding of the underlying workings of how small firms can overcome their liabilities of smallness, offering guidance to decision-makers in SMEs: We suggest managers to focus on the dynamic capabilities of their firms in order to sustain economic turbulences more effectively.

Most directly, we contribute to an ongoing debate among policymakers and researchers on the vulnerability of SMEs (Audretsch, 2002; Eggers, 2020). Policymakers and academics have increasingly focused on the financing conditions of small firms. For example, Fig. 6 (Appendix) shows that about every other speech by respective ECB presidents in the aftermath of the Global Financial Crisis discussed SMEs' access to credit. Our insights into this debate are crucial, given the significant policy initiatives launched in the advent of the crisis. In his infamous speech, the former ECB president Mario Draghi announced he would do "whatever it takes" to safeguard the European economy and, in particular, its SMEs. As a consequence, in the US and in Europe, regulators initiated massive programs in support of small firms, such as the Outright Monetary Transaction (OMT) program by the ECB or the Troubled Asset Relief Program (TARP) in the US.

Research has shown that these programs stimulated credit supply, softening SMEs' financing constraints both in the US and Europe (e.g., Li 2013; Ferrando et al. 2019; Udell 2020). Unsurprisingly, these large-scale programs stimulated access to bank financing and stabilized the banking sector as a whole. Yet, most studies remain silent on the efficiency of the respective programs. In fact, evidence suggests that the ECB's OMT program led to credit misallocations that slowed economic recovery (see Acharya et al. 2019). Our find-

ings corroborate this perspective, suggesting that policymakers should place more emphasis on specific characteristics of bank-dependent firms to define potential exposures to crises instead of mere size delineations. This aspect is particularly important given the strong focus of policymakers on designing structural help programs using merely size-based measures. We thus provide new insights into the underlying reasons why the massive policy initiatives in the aftermath of the Global Financial Crisis lacked precision.

5.2 Generalizability, limitations, and future research

Financial crises mark extraordinary periods that can fundamentally affect firm dynamics. Our empirical analysis relies on one specific crisis and one specific set of firms—the Great Financial Crisis and German SMEs. Still, its implications are likely generalizable to other crises and other types of firms.

The results of our analysis are likely applicable to other crises, including equally significant shocks like the COVID-19 pandemic. In general, recessions typically hit firms with a sudden decline in demand for their output. Under these conditions, firm revenues typically drop, while their obligations to cover operating costs and to serve creditors and suppliers remain (see, e.g., Gourinchas et al. 2020). In what follows is that economic activity is shaped by uncertainty until demand eventually reaches a pre-crisis level. Along these lines, the Great Financial Crisis is not notably different to other crises, such that the general workings of how SMEs react to it are likely similar. What is different, however, is the triggering circumstances and the severity of the crisis. Important in terms of generalizability is the magnitude of the Global Financial Crisis. In this regard, our settings stand out as we focus on a particularly harsh crisis (see Section 2.3). Our results highlight the resilience of German SMEs during these times, suggesting that they should sustain more moderate recessions as well.

In a similar vein, the findings of our paper likely apply to SMEs outside of Germany, too. Studying German SMEs is advantageous given the importance of banks as a primary source of external financing for investments. Similar to many other countries, in Germany, the SME sector is of central importance for the country's economic activity (Audretsch, 2002; Audretsch & Elston, 2002; De Massis et al., 2018;

Eggers, 2020). Likewise, the characterizing features of SMEs in Germany (i.e., opacity and bank dependence) do not differ from those of SMEs in other countries. Overall, our results are, therefore, indicative for other settings—both in the past and in the future. Given the frequency in which firms undergo economic turbulences, this paper contributes to a central question in the literature of small business economics.

Nevertheless, our analysis remains subject to certain limitations. First, like all data-driven approaches, the generalizability of our empirical results has natural limits. Our study captures SMEs from one country, implying that industry characteristics or the regulatory environment may cause the implications to differ when considering other economies, in particular, those outside of Europe (see Udell 2020). As such, the European Sovereign Debt crisis that unfolded in 2010 for a subset of Euro-area countries, excluding Germany, followed the financial crisis. It triggered a series of effects within respective countries that likely differ from those observed in Germany. Moreover, our analysis captures the financing dynamics of already established SMEs to the crisis. In addition to this, it would be interesting for future research to focus more specifically on startups, such as entrepreneurial ventures, and on other operational adjustments, like innovation-related investments.

As another specificity, our empirical analysis leverages highly detailed and reliable financial information from administrative sources. The level of granularity enables us to dissect different dimensions of firm-level financial activities to an extent that is typically not possible with ready-to-use balance sheet information. Still, the high quality of the data comes at the cost of having relatively limited information on the corresponding banks, i.e., the financing supply side. Similarly, the data underrepresents very small and young firms as they are often not subject to the rigorous reporting requirements. An economy-wide mapping of bank-firm links at the level of granularity of our data would certainly help future research to further advance our understanding of SME vulnerability in times of economic crises.

6 Conclusion

SMEs contribute significantly to economic growth and prosperity. However, these firms are often considered particularly prone to adverse economic shocks—an

observation questioned by both anecdotal and previous empirical analysis. This paper investigates the dynamics of financing constraints, focusing on the role of firm size in the German economy. Germany is historically considered a bank-based economy and, thus, suggests that the scarcity of funding opportunities stemming from the banking sector is a good indication of an actual worsening of firms' ability to obtain financing.

The analysis shows that SMEs are not disproportionately affected by the banking crisis. Indeed, before and during the crisis, the average SME exhibited a higher probability of being financially constrained. However, we find robust evidence that the effect of the crisis on financial constraints is not significantly greater for small firms than for large ones. In the post-crisis years, we observe a deleveraging trend for both financially constrained SMEs and constrained large firms. Regarding the longer-term implications of the slowdown in economic and financing activities, we find that SMEs persistently build up cash buffers, potentially substituting cash holdings for debt. Further, both financially constrained SMEs and financially constrained large firms recovered from the crisis similarly by regaining profitability, investments, and growth.

Our results highlight that firms' size cannot determine the intensity of financial constraints per se. Instead, non-bank funding alternatives and internal funds are most important in mitigating financial constraints. The analyses provide new evidence on the vulnerability of small, bank-dependent firms in the context of the largest banking-based economy worldwide.

Acknowledgements We especially thank two anonymous referees and editor Julie Ann Elston for numerous comments and suggestions. We are also thankful for fruitful discussions and comments by seminar participants at Copenhagen University, Goethe University Frankfurt, Norwegian School of Economics, Annual Congress of the Verein für Socialpolitik (German Economic Association) 2020, the Fourth ERMEES Macroeconomics Workshop 2021, the 11th RCEA Money, Macro, and Finance Conference 2021, International Risk Management Conference 2022, and Royal Economic Society Annual Conference 2023 for their comments and suggestions. We thank the Research Data and Service Centre (RDSC) of Deutsche Bundesbank in Frankfurt for their hospitality and support. The project number at Bundesbank is 2018\0051 and the data was obtained via a secure on-site access (Gafo). The article reflects the opinions of the authors only and does not express the view of Deutsche Bundesbank nor should it be attributed to the institution. All remaining errors are our own.

Funding Open access funding provided by Politecnico di Milano within the CRUI-CARE Agreement. David Heller received funding by the European Union – NextGenerationEU, Mission 4, Component 2, in the framework of the GRINS – Growing Resilient, INclusive and Sustainable project (GRINS PE00000018 – CUP XXXXX). The views and opinions expressed are solely those of the authors and do not necessarily reflect those of the European Union, nor can the European Union be held responsible for them.

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